POTOMAC INSTRUMENTS INC.

INSTRUCTION MANUAL

FIELD STRENGTH METER
FIM-21

POTOMAC INSTRUMENTS, inc.
932 PHILADELPHIA AVENUE
SILVER SPRING, MARYLAND 20910

PI

POTOMAC INSTRUMENTS, INC.

SILVER SPRING, MARYLAND

CERTIFICATE OF CALIBRATION

Field Intensity Meter Type FIM-21 Serial No. 178

This instrument was calibrated in an induction field of 220.0 millivolts per meter. At each measurement frequency the measured field was recorded and a correction factor K was computed; the indicated field must be multiplied by K to obtain the true field.

For some instruments a second factor K_{10} is given for use only with measurements made on the 10 volts-per-meter full scale range. K_{10} is supplied only when applicable.

KHz	K	K_{10}	KHz	K	K_{10}
540	0.991		1100	1.000	
600	0.991		1200	1.000	
700	0.991		1300	1.000	
800	1.000		1400	1.000	
900	1.000		1500	1.000	
1000	1.000		1600	1.005	

Single frequency of KHz only, K

The calibrating field is maintained equal to the National Bureau of Standards standard field within an accuracy of 1.0 per cent. NBS states that the absolute accuracy of its field is "believed to be within 3.0 per cent".

The error at points on the meter scale other than the calibration point is less than 3.0 per cent. The attenuator ratios are correct within 2.0 per cent. These accuracies apply for battery voltages that are indicated by the instrument's battery check circuit to be useable.

NEXT RECOMMENDED CALIBRATION DATE October 1974

Calibrated by Lynn D Catino Date Oct. 13, 1972

STATE OF MARYLAND

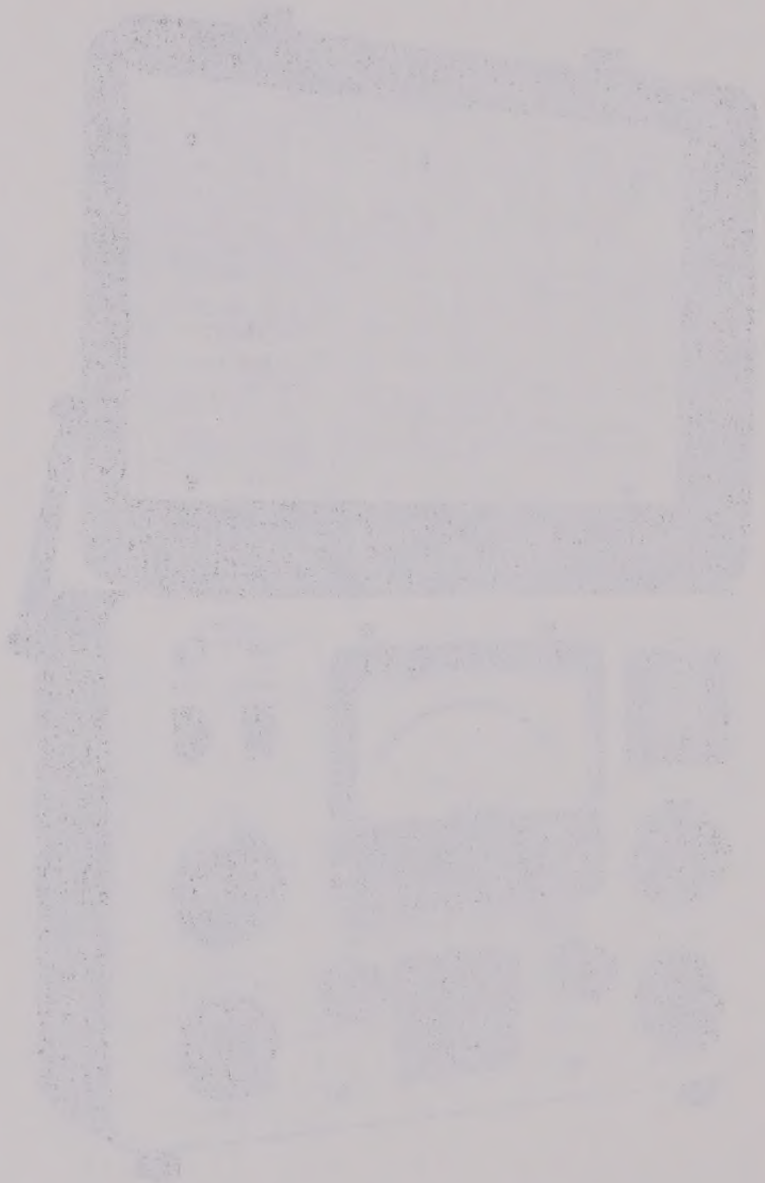
Personally appeared before me this 13th day of October 19 72,

Lynn D. Catino, who testified under oath that the above calibration was made either by himself or under his direction and that the statements in the above certificate are true to the best of his knowledge and belief.

INSTRUMENT SERVICES

FIELD STRENGTH METER
FIM-21

POTOMAC INSTRUMENTS inc.
PRECISION ELECTRONIC PRODUCTS
932 PHILADELPHIA AVENUE / SILVER SPRING, MARYLAND 20910



WARRANTY FOR EQUIPMENT AND ACCESSORIES

Potomac Instruments inc. warrants each new equipment to be free of defects in material and workmanship, for a period of one (1) year after date of original shipment, except for tubes, lamps, fuses, transistors, and diodes which will be warranted for a period of ninety (90) days. Any instrument which is found within one year not to meet the foregoing standards after examination by our factory, will be repaired or at the option of Potomac Instruments replaced without charge. This warranty does not apply to equipment which has been altered, improperly handled, or damaged in any way.

CHANGES IN SPECIFICATIONS

The right is reserved to change the published specifications of equipment at any time, and to furnish merchandise in accordance with current specifications, without incurring any liability to modify equipment previously sold.

RETURNING EQUIPMENT TO THE FACTORY

Factory service is available for repair and adjustment of this instrument; however, a description of the trouble, plus the model and serial number(s) of the unit should be forwarded first, whereupon instructions for correcting the trouble or authorization for returning the equipment will be given. This applies to all units, whether under warranty or not. Shipment in an improper container may result in damaged equipment thereby voiding warranty.

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SECTION 1. GENERAL DESCRIPTION

1.1 Scope of Manual

This manual provides a comprehensive technical description of the operating and physical characteristics of the FIM-21 and FIM-41 Field Strength Meters. It provides sufficient information concerning the operation and functional theory of operation to permit effective operation of these instruments.

1.2 Purpose of Equipment

Field Strength Meters, FIM-21 and FIM-41 are light-weight portable instruments for the measurements of a wide range of radio signal intensities in the .54 to 5.0 MHz frequency spectrum. The FIM-21 covers the broadcast band (540 to 1600 KHz) while the FIM-41 covers the broadcast band and harmonic frequencies to 5.0 MHz. Both units are rugged test instruments that are equally effective for interference studies at low signal strength and for close-in measurements on high-power directional arrays. In addition, a special input jack permits the receiver to be used as a null detector for RF Bridge measurements.

1.3 Equipment Specifications

(See specifications, FIM-21, Table 1-1, FIM-41, Table 1-2)

Table 1-1. Specifications: Type FIM-21 Field Strength Meter

Frequency Range:	535 KHz to 1605 KHz
Field Intensity Range:	10 microvolts per meter to 10 volts per meter
Accuracy of Calibration:	1 percent, referenced to NBS Standard Field
Accuracy of Range Attenuator:	2 percent over entire FI range and tuning band
Selectivity	
Bandwidth (6 db):	7 KHz nominal with multi-pole hybrid filter
IF Rejection:	75 db minimum
Image Rejection:	80 db minimum
Adjacent Channel Rejection:	50 db minimum 10 KHz above and below tuned station
Panel Meter:	4" mirrored scale, logarithmic graduations 1 to 10, taut band meter movement, 2% linearity
Antenna:	Shielded loop, integral part of hinged cover

Table 1-1. Specifications: Type FIM-21 Field Strength Meter (Cont.)

Audio Outputs:	Front panel loudspeaker, weather treated cone Headphone jack, high and low Z (disconnects speaker)
Recorder Output:	0.4 to 4 volts DC proportional to field intensity for each attenuator range, 2000 ohm source resistance
Lights:	Frequency dial and meter; panel switch for night use
Batteries (6 required):	Standard $1\frac{1}{2}$ volt C-Z_n "D" cells or $1\frac{1}{2}$ volt Alkaline cells for extended life at very low temperatures
Battery Life:	Greater than 1000 FI readings (reduced life with frequent use of lights and/or high speaker volume)
Environmental:	Continuous exposure -10° F to +130° F; lower temperature operation practical for "reading time" exposures
Dimensions:	8-3/4" high, 11-1/2" wide, 5-1/8" deep with cover closed; 3-7/8" deep with cover open (gripping width)
Weight:	Approximately 11-1/2 pounds
External RF Input:	535 KHz to 1605 KHz, 10 microvolts to 10 volts
RF Input Switch:	Selects loop antenna (ANT) or Panel Connector (EXT)
METER Switch:	Selects normal linear (LIN) or logarithmic (LOG) operation
Logarithmic Dynamic Range:	60 db compressed input range for FI meter and recorder output

Table 1-2. Specifications: Type FIM-41 Field Strength Meter

Frequency Range:	.54 MHz - 5.0 MHz in two bands Band "A" .535 - 1.61 MHz Band "B" 1.58 - 5.0 MHz
Field Strength Range:	10 microvolts per meter to 10 volts per meter
Accuracy of Calibration:	1 percent, referenced to NBS Standard Field
Accuracy of Range Attenuator:	2 percent over entire FI range and tuning band
Selectivity Bandwidth (6 db):	7 KHz nominal with multi-pole hybrid filter
IF Rejection:	75 db minimum
Image Rejection:	80 db (min.) at 540 KHz decreasing to 50 db (min.) at 4.8 MHz
Adjacent Channel Rejection:	50 db minimum 10 KHz above and below tuned station
Harmonic Measurement:	Capable of measuring harmonics in excess of 80 db below fundamental
Panel Meter:	4" mirrored scale, logarithmic graduations 1 to 10 and linear db scale; taut band meter movement, 2% linearity
Antenna:	Shielded loop, integral part of hinged cover
Audio Outputs:	Front panel loud speaker, weather treated cone - headphone jack, high and low Z (disconnects speaker)
Recorder Output:	0.4 to 4 volts DC proportional to field strength for each attenuator range, 2000 ohm source resistance
Lights:	Frequency dial and meter with panel switch for night use
Batteries:	Standard 1-1/2 volt C-Z_n "D" cells or 1-1/2 volt. Alkaline cells for extended life at very low temperatures (six required)

Table 1-2. Specifications: Type FIM-41 Field Strength Meter (Cont.)

Battery Life:	Greater than 1000 readings (reduced life with frequent use of lights and/or high speaker volume)
Environmental:	Continuous exposure -10° to +130° F; lower temperature operation practical for "reading time" exposures
Dimensions:	8-3/4" high, 11-1/2" wide, 5-1/8" deep with cover closed; 3-7/8" deep with cover open (gripping width)
Weight:	Approximately 12 pounds
External RF Input:	540 KHz to 5.0 MHz, 10 microvolts to 10 volts
RF Input Switch:	Selects loop antenna (ANT) or Panel Connector (EXT)
METER Switch:	Selects normal linear (LIN) or logarithmic (LOG) operation
Logarithmic Dynamic Range:	60 db compressed input range for FI meter and recorder output
Accessories Available:	Carrying/Shipping case Unipod

SECTION 2. OPERATION

2.1 General

The FIM-21 and FIM-41 operating controls and indicators are described in this section. Also provided are the basic operating instructions which include battery voltage testing, meter calibration, measuring field strength, and use of these instruments as null detectors for RF Bridge measurements.

2.2 Operating Controls and Indicators

All operating controls and indicators are located on the front panel of the FIM-21 and FIM-41 as shown in figure 2-1. Table 2-1 lists these controls and indicators and the associated functions.

Table 2-1. Operating Controls and Indicators

Control or Indicator	Function
FUNCTION selector switch (S2)	Selects the function to be displayed on the front panel meter and connects battery. OFF - battery disconnected from circuit, and direct connection made across meter terminals to protect meter. BATT - battery output voltage FI CAL TUNE - field strength of antenna input developed from detected output of receiver IF amplifier. CAL Null - compares detector outputs from receiver and calibrating oscillator.
FULL SCALE selector switch (S1)	Selects the amount of attenuation in RF and IF stages, in 10 to 1 (20 db) ratio steps. The panel is marked with the full-scale direct-reading field strength value for each position. CAL - applies power to calibrating oscillator, and selects 1 volt range of attenuator.
AUDIO control and switch (R3)	Adjusts level of audio in speaker and headphones. Switch disables audio amplifier in OUT position.

Table 2-1. Operating Controls and Indicators (Cont.)

Control or Indicator	Function
GAIN control (R2)	Adjusts gain of receiver by regulating gain of IF amplifier.
CAL OSC tuning control (R1)	Fine tunes calibrating oscillator. (Oscillator frequency coarse tuning is pre-set by receiver tuning control.)
RCVR tuning control (C1)	Tunes receiver and calibrating oscillator by rotating capacitors C1 and C2. Frequency of receiver signal is read on dial.
FIELD-STRENGTH meter (M1)	Indicates field strength in volts per meter, in conjunction with full scale switch.
LIGHT switch (S3)	Illuminates meter and dial.
RF INPUT switch	Switches receiver input to loop antenna (ANT) or external BNC input jack (EXT).
MHz switch (FIM-41 only) (S7)	Selects frequency band: A. .54 to 1.6 MHz B. 1.6 to 5.0 MHz
METER switch (S5)	Provides either logarithmic (LOG) or linear (LIN) relation between meter reading and receiver input, the former for use when the meter is to operate in conjunction with recording equipment or when relative measurements of greater than one decade are desired.

Replacement of batteries is described in the maintenance section of this manual.

2.3 FIM Calibration

The FIM should always be calibrated at the frequency of the signal to be measured. This eliminates any error due to frequency sensitive components in the circuits. Calibrate the meter as follows:

1. Place or hold the field strength meter in a vertical position, with the top surface in a horizontal plane. Open the cover and swing it to a vertical position.

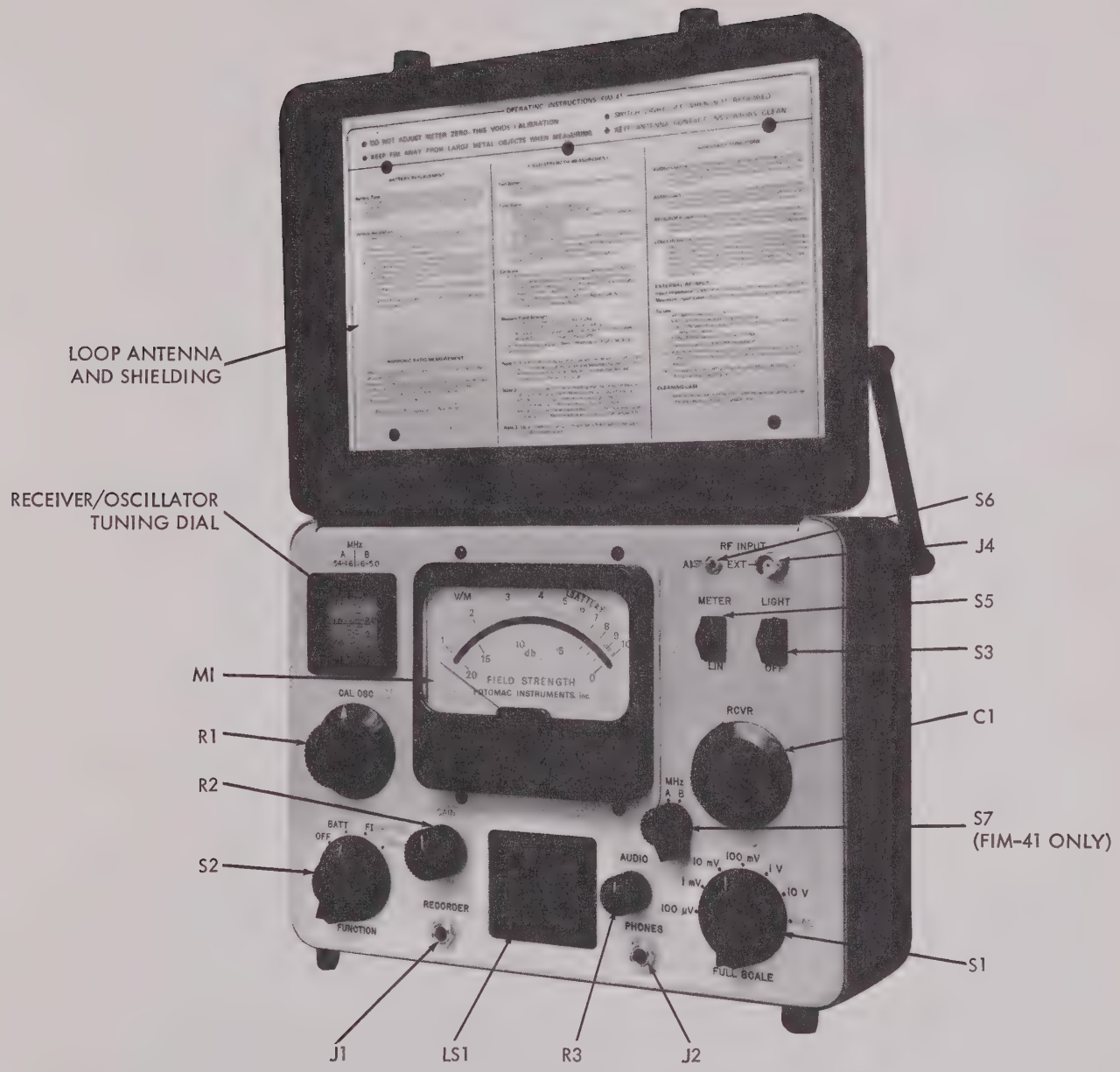


Figure 2-1 Operating Controls and Indicators

2.3 FIM Calibration (Cont.)

2. Rotate the FUNCTION switch to the BATT position and see that the reading is above 5.0.

3. Rotate the FUNCTION switch to the FI position.

4. Switch LOG-LIN switch to LIN position.

5. Set the FULL SCALE switch to the range which covers the expected value of field strength.

6. Turn on the AUDIO control and tune the RECEIVER dial to the signal to be measured. Use the meter indication to obtain peak tuning, adjusting the GAIN control and FULL SCALE switch, and rotating the instrument to obtain a reading within the range of the meter. Use the audio signal to identify the station. The RCVR Tuning Control has vernier drive for 3/4th of one turn; it changes to direct drive and becomes harder to turn beyond the vernier range. Adjust it so that the desired station falls in the vernier range.

7. Rotate the instrument to obtain reading below 10 mV. In strong fields the meter reading may be reduced below 10 mV by holding the FIM horizontally or by changing RCVR Tuning away from the desired signal by no more than 10 KHz. (This is permissible because the receiver gain variation with frequency is very gradual.) An indistinct dip in the meter reading in Step 8 indicates inadequate reduction of the received signal, or interference.

8. Place the FULL-SCALE switch in the CAL position: adjust CAL OSC Tuning for highest meter reading, or an audio beat note low enough in frequency to be inaudible. (The meter reading should be 3.5-4.8 when the Gain control is properly set.)

9. Rotate FUNCTION switch to CAL NULL position: adjust GAIN control for lowest meter reading. The meter reading should be below 3.0.

10. Return FUNCTION switch to FI-CAL-TUNE. Retune RCVR tuning for maximum meter reading on the desired signal. The Field Strength Meter is now calibrated at the frequency to which it was originally tuned.

2.4 Measuring Field Strength

In use, the field meter is generally held in the hand, or mounted on a tripod or unipod. Of the latter two, the unipod is preferred, since it can be easily rotated, and can remain attached to the instrument. A plate having a hole tapped for a $\frac{1}{4}$ - 20 screw is fastened to the bottom of the case, for attachment to a support.

2.4 Measuring Field Strength (Cont.)

The field meter should always be operated in a vertical position when making field strength measurements.

After calibrating as described in the previous section, proceed as follows:

1. Set the FULL SCALE switch to the range approximating the signal strength expected.

2. With the FUNCTION switch set at FI, rotate the unit to orient the loop antenna and obtain maximum deflection on the panel meter, changing the position of the FULL SCALE switch if necessary to keep the panel meter indication on scale.

3. Read the field intensity directly from the panel meter, using the position of the FULL SCALE switch as a guide. For example, with the FULL SCALE switch on 100 mv, a full scale reading of 10 on the meter means 100 millivolts per meter, and a reading of 5.6 indicates a field strength of 56 millivolts per meter.

4. Multiply the reading obtained in step 3 by the K factor for the operating frequency given on the calibration certificate for the instrument. This procedure is followed when it is necessary to make full use of the specified accuracy of the field meter.

5. To de-energize the field meter, rotate the FUNCTION switch to the OFF position. This disconnects the batteries from the circuit. Closing the cover also removes the battery power.

2.5 Measuring Harmonic Ratio in Decibels

Field Strength Ratios may be measured directly in decibels by reading the db scale of the meter in conjunction with the FULL-SCALE range indicator. Since each step of the FULL-SCALE switch corresponds to one (1) decade or twenty (20) db, the ratio is determined by the following formula:

$$db_1 - db_2 + N \times 20 = \text{Ratio in db}$$

where:

db_1 = Harmonic field strength
db_2 = Fundamental field strength
N = Number of FULL SCALE steps between fundamental and harmonic

2.5 Measuring Harmonic Ratio in Decibels (Cont.)

Example:

Let us say that we want to measure the field strength and the second and third harmonic suppression of a transmitter with an operating frequency of 1500 KHz.

1. Measure field strength of fundamental as outlined in section 2.4 of this manual; note db scale. Example: 560 mV/M & 5 db.

2. Measure field strength of second harmonic as above at 3.0 MHz. Example: 0.35 mV/M & 9 db.

3. Measure field strength of third harmonic as above at 4.5 MHz. Example: 79 uV/M & 2 db.

Calculate harmonic suppression:

$db_1 - db_2 + 20 \times N = \text{ratio (db)}$

second harmonic suppression = 9-5 + 60 = 64 db

third harmonic suppression = 2-5 + 80 = 77 db

It is not the purpose of this manual to describe the techniques of locating radial measurement points and plotting the field data required by the FCC. For this type of information, and for a more detailed description of operating techniques, the user is referred to the current edition of the NAB Handbook.

2.6 R. F. Bridge Measurements (Tuned Voltmeter)

The receiver section of the FIM-21 and FIM-41 may be used as a tuned voltmeter for applications such as R. F. Bridge null detection. As a tuned voltmeter, these instruments exhibit an input impedance of 2500 ohms shunted by less than 2 picofarads.

To use the FIM as a relative indicator of RF voltage, proceed as follows:

1. RF INPUT switch	switch to EXT position
2. METER switch	LOG or LIN - the LOG mode is helpful for RF null detection work
3. FUNCTION switch	set to FI-CAL TUNE
4. FULL SCALE switch	set to 10V position or as required for meter indication

2.6 R. F. Bridge Measurements (Tuned Voltmeter) (Cont.)

Connect RF source to EXT RF input on FIM front panel. Adjust RCVR tuning for desired frequency and highest reading: adjust FULL SCALE switch for an on-scale reading.

To calibrate the FIM for absolute voltage measurements; set RCVR tuning to desired frequency with signal source connected to EXT RF input switch settings as in steps 1, 3 & 4 above. The LOG-LIN switch must be set to the LIN position for absolute readings. Switch the RF INPUT switch to ANT and calibrate meter as described in Section 2.3. Return RF INPUT switch to EXT and read meter. The correct voltage is obtained by correlating the meter indication and the FULL SCALE attenuator setting as previously described.

IMPORTANT NOTE

When operating the FIM as a tuned voltmeter, it is necessary to guard against severe overload at the EXT RF input. For this reason, start all measurements in the 10V FULL SCALE switch position. The maximum input level which can be applied to EXT input without causing damage is 25 volts RMS.

SECTION 3. THEORY OF OPERATION

3.1 General

The theory of operation of Field Strength Meters FIM-21 and FIM-41 is explained in this section. Included in this section is a general description which is referenced to the associated block diagram.

3.2 Block Diagram Description

Refer to Figure 3-1, Field Strength Meter FIM-21/41, Functional Block Diagram.

The FIM can be considered as being made up of seven major sections:

(1) A loop antenna

(2) A very stable AM superheterodyne receiver

(3) A 20 db per step RF/IF attenuator within the receiver

(4) A calibration oscillator

(5) A gain comparison (null) circuit

(6) A panel meter

(7) A regulated power supply

A shielded loop antenna is used because of its directivity characteristic and its freedom from hand capacity effects. Signals picked up by it are fed into the receiver, and the carrier to be measured is selected by tuning the receiver, using headphones, or the panel speaker, and the panel meter as tuning indicators. Both the audio and the DC to operate the meter are obtained from a diode rectifier at the output of the last IF stage.

The RF attenuator is set to the range which provides a reading between the upper and lower limits of the meter, and the instrument is rotated for maximum pickup in the loop. The six steps in the attenuator, plus the 10 to 1 range of the meter, make it possible for the instrument to measure signals over a range of 10 microvolts to 10 volts.

With the loop-receiver-meter section of the field meter just described, it is possible to make comparative or relative field measurements over a wide range, and the shape of the radiated pattern can be determined with accuracy. However, the FCC requires the broadcaster to make absolute measurements of the signal intensity at any point, in volts per meter, and for this purpose the calibration oscillator is included.

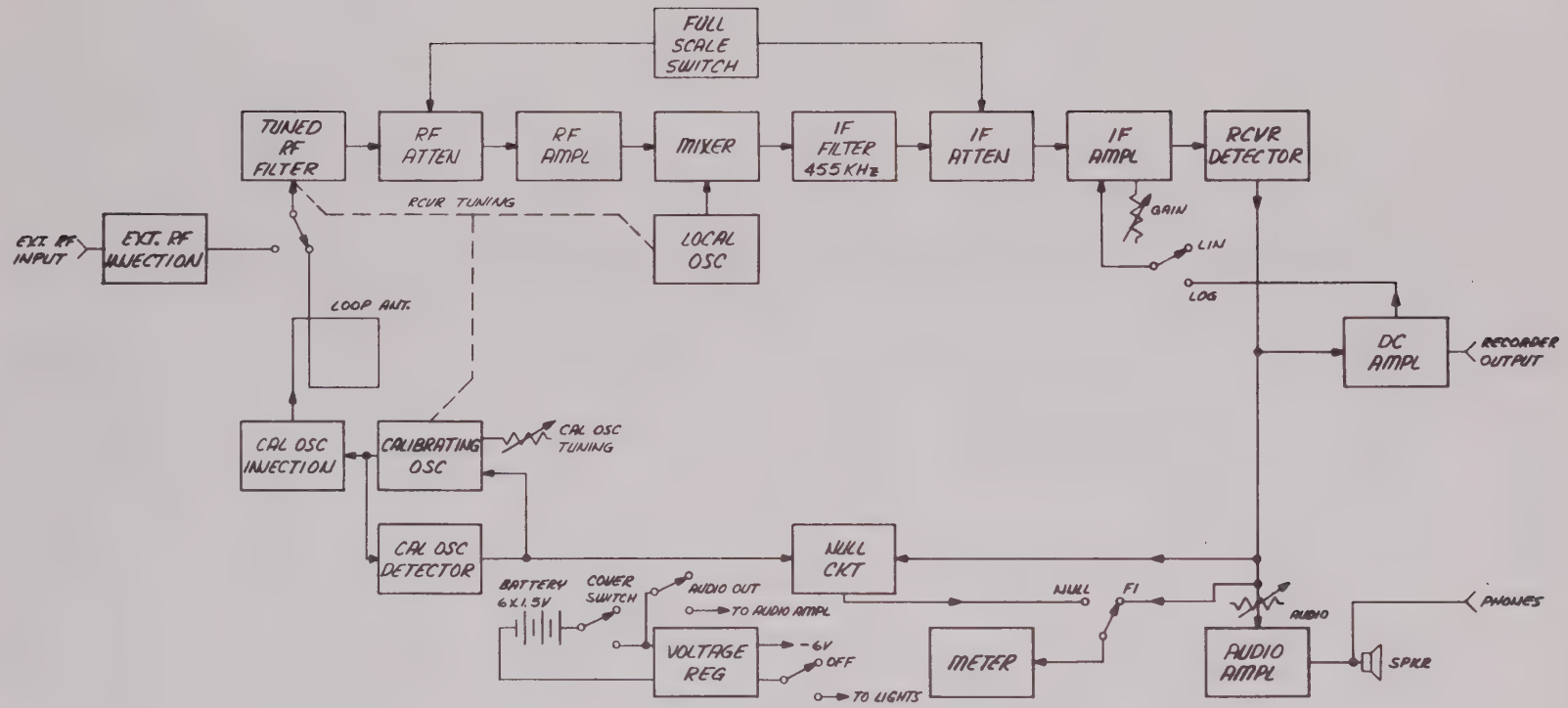


Figure 3-1 Field Strength Meter, Functional Block Diagram

3.2 Block Diagram Description (Cont.)

If the user were to hold the field meter at a precise point in a radiated field known to have a strength of 200 MV/M, and adjust the receiver gain to read this value on the meter, the instrument would then be calibrated at this frequency and it would read field strength in volts per meter at all measuring points, provided that the gain does not change, and that the receiver tuning does not change.

To calibrate the field meter, then, it is only necessary to have some reference signal in the receiver to indicate the proper setting for the receiver gain control. This signal is provided by the calibration oscillator.

When the FULL SCALE switch is positioned to CAL, and the FUNCTION switch is positioned to FI, a precisely-determined fraction of the oscillator output voltage is injected into the receiver antenna circuit and is detected by the receiver. At the same time a detector fed directly by the oscillator output voltage provides a dc voltage for comparison with the receiver detector output.

In the FIM-21 and FIM-41 the two detector outputs that must be equalized are compared using a null circuit. The null circuit produces a meter reading that drops as the receiver detector voltage approaches the oscillator detector voltage from above or below; the reading is minimum when the voltages are equal. The receiver gain value for which the detector outputs are equal is determined by the relation between the RF voltage at the oscillator detector and the RF voltage injected into the antenna circuit. The circuitry that determines this injection voltage thus determines the calibration accuracy. The circuitry is factory-set during final calibration for correct field readings. Since the voltage induced in the antenna by a field varies with frequency, the RF injection voltage must also vary with frequency in exactly the same way in order for the calibration to be correct across the full frequency range. The desired variation with frequency is produced by a simple reactive network.

It is the double function of the calibration oscillator, as a signal source for the receiver and as a reference level for the null circuit, that provides the very important self-compensating feature of the calibration of this instrument. For example, if the output of the oscillator were to be reduced by 20% for any reason, the reference level for the null circuit would be 20% lower, but the signal fed into the loop would also be 20% lower, so that no change in the gain control would be required to calibrate.

3.3 Circuit Description - Refer to Figure 3-1

In the receiver the RF signal is induced by the magnetic component of the incident field in a shielded, unbalanced loop antenna. The loop is part of the first tuned circuit of a double-tuned bandpass filter that is tuned over the RF frequency range. The input can also be supplied from an external source; selecting this mode switches the loop antenna out of the circuit while maintaining the same RF bandpass characteristics.

3.3 Circuit Description (Cont.)

A capacitive voltage divider RF attenuator follows the RF filter. It is switched by the FULL SCALE switch in three 20 db steps to provide part of the total measurement range. The attenuator output drives a broadband RF amplifier and mixer. The oscillator driving the mixer is tuned over the RF range to produce an IF frequency of 455 KHz.

The IF signal passes through a ceramic filter that, in conjunction with the RF tuned circuits, provides receiver selectivity. The signal is then fed to a resistive attenuator having two 20 db steps. Following the attenuator is the IF amplifier, made up of broadband stages with tuned circuits at input and output. IF gain is controlled by a front panel control, and also, in the LOG mode, by a voltage fed back from the detector. The IF detector at the amplifier output supplies voltages to the meter, the audio circuit, and calibrating circuit, and to a simple dc amplifier that provides the RECORDER output.

The audio amplifier drives a speaker or an external load. A switch on the front-panel AUDIO control removes power from the amplifier when audio is not needed, in order to reduce battery drain.

A calibrating oscillator, gang-tuned with the receiver, provides a signal at the selected frequency for self-calibration. A front-panel control provides a fine frequency adjustment for exact tuning. The dc voltage from a detector at the oscillator output is compared with the voltage from the receiver detector in a null circuit, which produces a dip in the meter reading when the two voltages are equal. A portion of the oscillator RF voltage is injected into the receiver in such a way that, when the receiver gain is adjusted for a null circuit dip, correct field readings will be obtained when the oscillator is switched off.

DC power is supplied by six 1.5 volt cells in series and a simple voltage regulator that has an output of -6.0 volts. A battery check circuit indicates battery condition on the meter. It is adjusted to indicate battery replacement at a total voltage of 6.6 volts.

SECTION 4. MAINTENANCE

4.1 General

Routine maintenance procedures are explained in this section, including changing batteries. Since circuit alignment and linearity adjustment must be performed at the factory to maintain guaranteed calibration of the instrument, this information is not included in this manual.

4.2 Battery Replacement

1. Place FIM with battery door (on rear) facing up.

2. Turn door fasteners $\frac{1}{4}$ turn to left (slots vertical); open door.

3. Remove old batteries, prying out center ones first.

4. Install new batteries, starting with the bottom row and left side. Observe polarity; positive contacts are to the left in the bottom row, to the right in the top row. Install the two right-hand batteries last, the bottom one first, using them to push back the spring-loaded contact board.

5. Close door and turn fasteners $\frac{1}{4}$ turn to right (slots horizontal) to lock.

4.3 Battery Types

Use Size D.1.5 volt batteries of any type. Alkaline batteries are desirable only if the lights are used frequently or if the FIM is used when its internal temperature is about 40° F. Storage of the FIM in a cool place extends battery life; heat shortens battery life.

4.4 Lamp Replacement

4.4.1 (Dial Lamp) Remove FIM from case. (See 4.5 below) Remove socket from lamp. Rotate lamp until the three projecting tabs on the side of the retaining clip are accessible.

a. Free the clip by pinching the tabs together with pliers and slide it off the lamp.

b. Remove the old lamp and slip the new one in place.

c. Holding the clip open with pliers, slip it in place on the new lamp.

d. Replace the socket.

e. Check lamps before installing unit in case as follows: connect battery connector, switch FUNCTION switch to BATT, open lid so as to close interlock switch, switch LIGHT switch on, and check that all lamps are working.

4.4 Lamp Replacement (Cont.)

4.4.2 (Meter Lamp) FIM-21, Serial Numbers 123 and higher.
FIM-41, All

a. Stand the FIM upright on a flat surface, with the cover open. Set switches as follows:

FUNCTION to OFF
LIGHTS to OFF

b. Remove the four socket-head screws directly above and below the meter, which fasten the meter panel to the front panel. Ease out the meter and panel and rest the meter face-down on a small block or other support.

c. The lamps should appear projecting from the main panel below the meter hole. Pull the bad lamp out far enough to grip the socket and pull it out of the socket. Be sure that the socket does not pull back inside the FIM when released.

d. Remove the rubber grommet or washer from the old lamp and slip it onto the new one from the back, pushing it up against the shoulder of the lamp.

e. Insert the new lamp in its socket and push the lamp into approximately the original position of the old lamp.

f. Repeat steps c-e for the other lamp if necessary.

g. Replace the meter and panel in the main panel, being certain that the lamps are properly seated in the meter and that the meter panel seats snugly against the main panel. Replace the four screws.

h. Check the new lamps for proper operation by switching the FUNCTION switch to BATT and the LIGHT switch on (red spot showing).

4.5 To Remove FIM from Case

1. Place upright on bench with the cover open. Tune to 540 KHz, remove the four screws retaining the spring arms, and slip off the spring arms (1/8" Allen wrench).

2. With the cover closed, remove the 12 screws holding the case to the front panel (5/64" Allen wrench).

4.5 To Remove FIM from Case (Cont.)

3. Place unit upright on bench with cover away from you; remove the cover-panel assembly from the case by pushing with the thumbs against the cover hinge while gripping the case. This assembly will stand upright by itself, but should have support under the dial end of the chassis for safety.

4. Unplug the battery connector (on top of chassis) to separate the two parts completely.

4.6 To Operate the FIM With Case Removed

The FIM may be operated by connecting the battery connector and opening the cover so as to close the interlock microswitch. It may be placed upright, with support under the chassis near the dial. For access to the circuit boards, it may be operated while resting on the end nearest the dial.

4.7 IC Replacement

It takes considerable force to extract an IC from its socket. It must be pried out by inserting a tool between the IC body and socket, or pulled out by means of a tool made for the purpose. Do not use an adjacent component as a fulcrum for prying. Because of the possibility of damaging an IC when removing it, do not remove it unless circuit checks show it to be defective. (See troubleshooting voltage charts, Figure 4-1.)

To install a new IC, first be sure that all pins fall in the center of their socket holes without forcing. In new IC's, each row of pins must usually be bent toward the other to achieve this. They can be bent by pressing each row of pins against a flat surface, or by use of suitable pliers, bending the pins as close to the body as possible. When the pins fit the socket, place the notched end of the IC at the notched end of the socket and press gently into place.

4.8 Preventive Maintenance

To maintain the FIM-21 and FIM-41 in good condition, regular cleaning and inspection is required at intervals depending on local conditions. If the unit is used frequently in dusty areas or rough country, more frequent checks are required. It should be cleaned and inspected after any extended period of hard use.

Remove all dust and dirt from the unit, using a damp cloth or sponge all over, and using a brush to remove dirt from crevices.

Clean the dial window and meter glass only with water and a mild detergent on a clean cloth. Do not use strong solvents, which can do much damage.

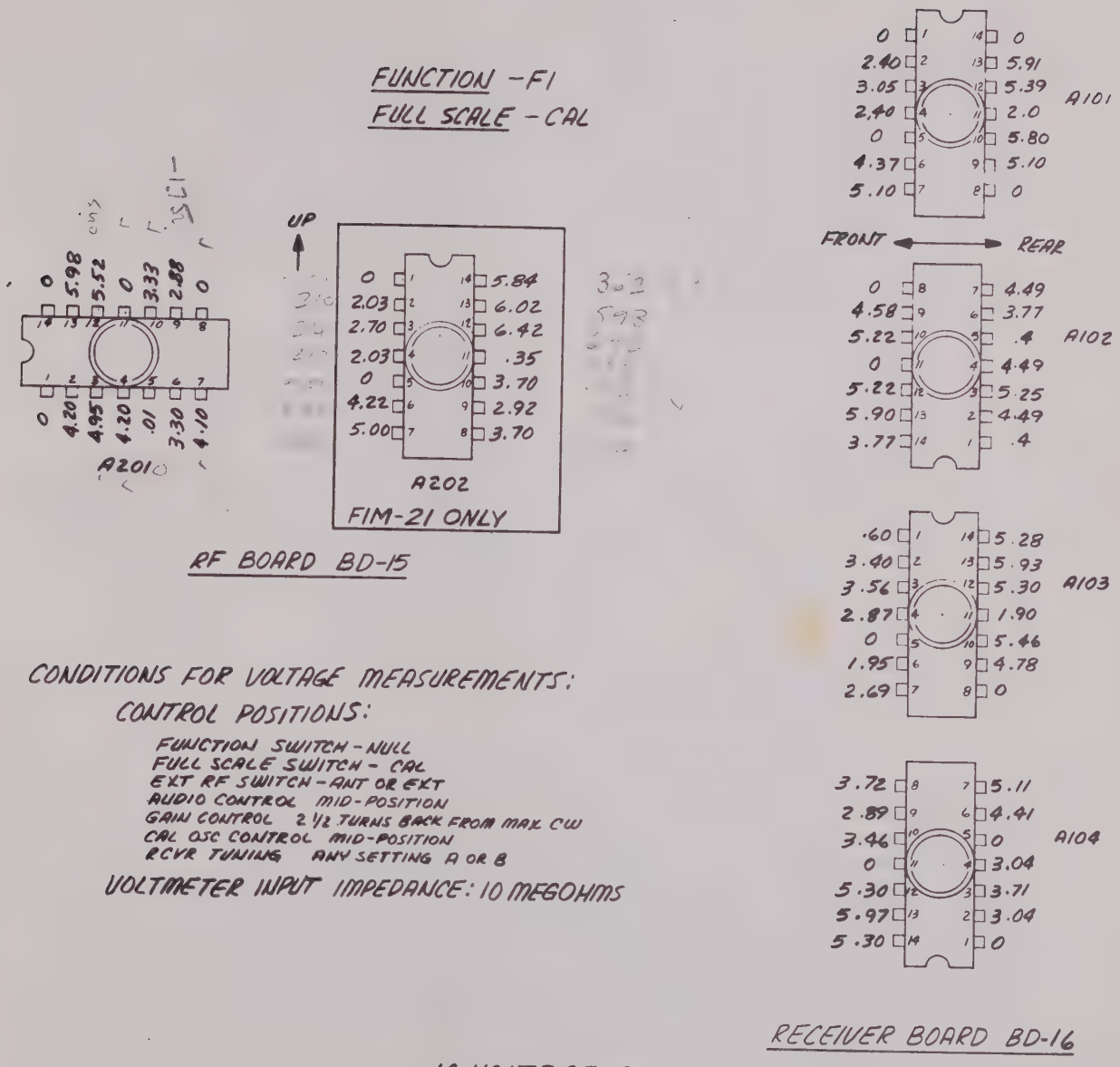

FUNCTION - F1
FULL SCALE - CAL
UP
0 5.98 5.52 0 3.33 2.88 0
0 4.20 4.95 4.20 .01 3.30 4.10
A201
0 2.03 2.70 2.03 0 4.22 5.00
5.84 6.02 6.42 .35 3.70 2.92 3.70
A202
FIM-21 ONLY
RF BOARD BD-15
0 2.40 3.05 2.40 0 4.37 5.10
0 5.91 5.39 2.0 5.80 5.10 0
A101
FRONT
REAR
0 4.58 5.22 0 5.22 5.90 3.77
4.49 3.77 .4 4.49 5.25 4.49 .4
A102
.60 3.40 3.56 2.87 0 1.95 2.69
5.28 5.93 5.30 1.90 5.46 4.78 0
A103
3.72 2.89 3.46 0 5.30 5.97 5.30
5.11 4.41 0 3.04 3.71 3.04 0
A104
RECEIVER BOARD BD-16
CONDITIONS FOR VOLTAGE MEASUREMENTS:
CONTROL POSITIONS:
FUNCTION SWITCH - NULL
FULL SCALE SWITCH - CAL
EXT RF SWITCH - ANT OR EXT
AUDIO CONTROL MID-POSITION
GAIN CONTROL 2 1/2 TURNS BACK FROM MAX CW
CAL OSC CONTROL MID-POSITION
RCVR TUNING ANY SETTING A OR B
VOLTMETER INPUT IMPEDANCE: 10 MEGOHMS
IC VOLTAGE CHART
FIM 21/41

Figure 4-1 Troubleshooting Voltage Charts

4.8 Preventive Maintenance (Cont.)

Thoroughly remove dust and dirt from the wells around the antenna contact plungers on top of the case, and from the fixed contact insulators on the cover. The insulators for both sets of contacts will appear white when clean. The wells are best cleaned with a cotton swab ("Q-Tip") or similar article. If the contacts should get wet, dry them as soon as possible.

Wipe any dust from the antenna contacts with a soft cloth. Do not use an abrasive (such as a pencil eraser) on them, as this will remove the gold plating.

When cleaning, inspect the unit for loose hardware and physical damage, and correct as necessary.

4.9 Troubleshooting and Repair

If the FIM-21 or FIM-41 appears to be functioning improperly, or not at all, systematic checks may be made to try to find the problem, at first without opening the unit. If the unit must be opened, internal components and connections can be identified by using the Component Location Diagrams, Figures 4-2 and 4-3, and the Schematic Diagram, Sec. 5.1.

Make checks as follows:

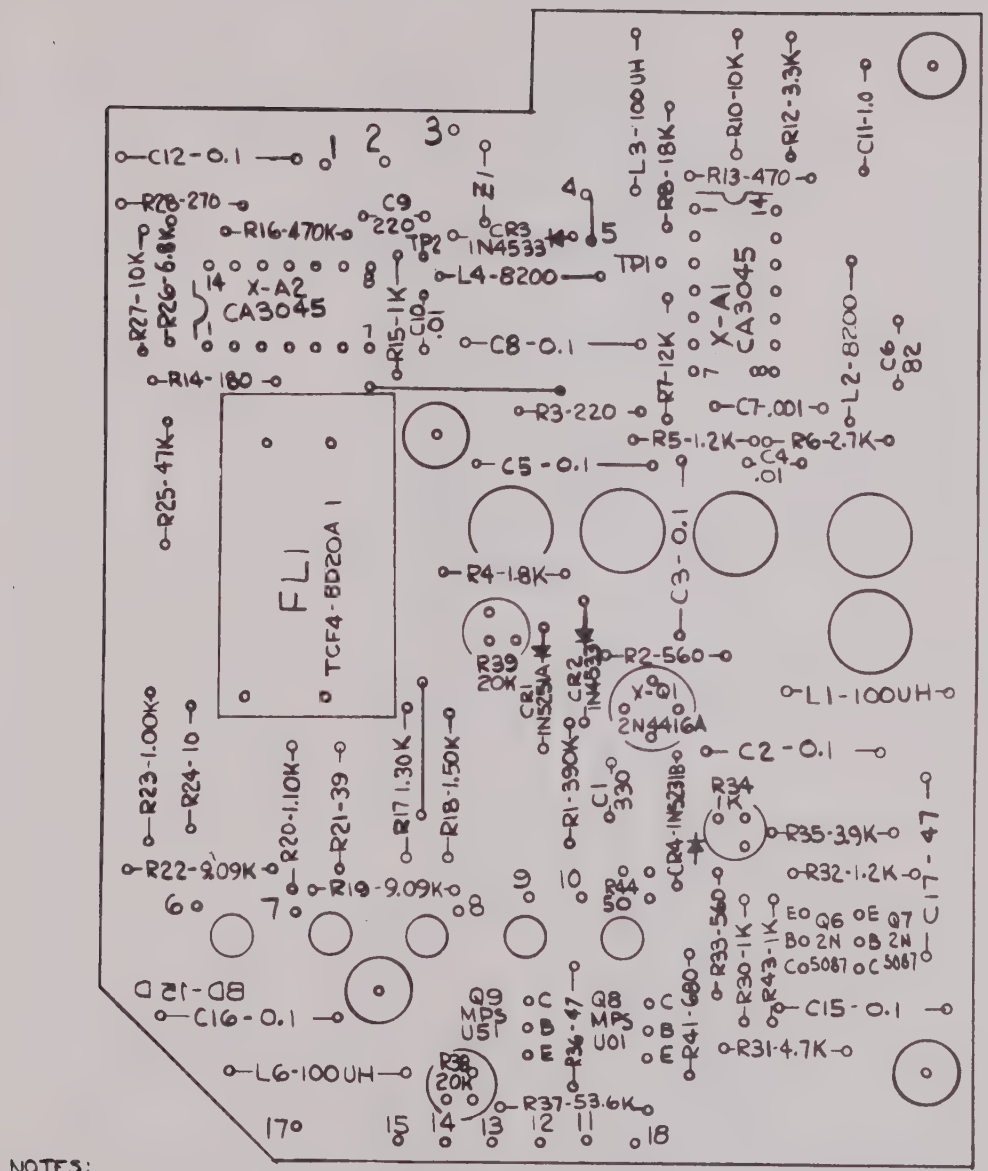
1. Check the setting of all switches, especially the RF INPUT and METER switches.

2. Check the battery voltage, with AUDIO and LIGHT switches on if they are normally used.

3. Determine whether the unit can be calibrated using the normal procedure. If no FI reading is obtained with the calibrating oscillator on (FULL SCALE switch at CAL), either the receiver or oscillator may be faulty. If an FI reading between 3 and 5 is obtained but no null can be obtained, the null circuit is probably faulty. The FI reading due to the oscillator should not vary more than 30 percent across the full frequency range; a large variation indicates an RF tuned circuit problem, which normally requires return to the factory. If the reading cannot be peaked within the range of the CAL OSC control, the calibrating oscillator tuned circuit needs adjustment.

4. Determine whether the FIM gives normal FI readings on several signals of known strength. This indicates whether the receiver is working properly.

5. Determine whether switching the AUDIO and LIGHT switch in and out affects field strength readings. If so, these circuits may be faulty, drawing excessive current, and the FIM may read correctly if they are left off.



NOTES:

1. CAPACITOR UNITS: 1.0 & SMALLER, μF
   GREATER THAN 1.0, pF
2. RESISTOR UNITS: OHMS; K = $\times 10^3$
3. INDUCTOR UNITS: μH
4. ADD 200 TO ALL REFERENCE NUMBERS

Figure 4-2 Field Strength Meter, Component Locations

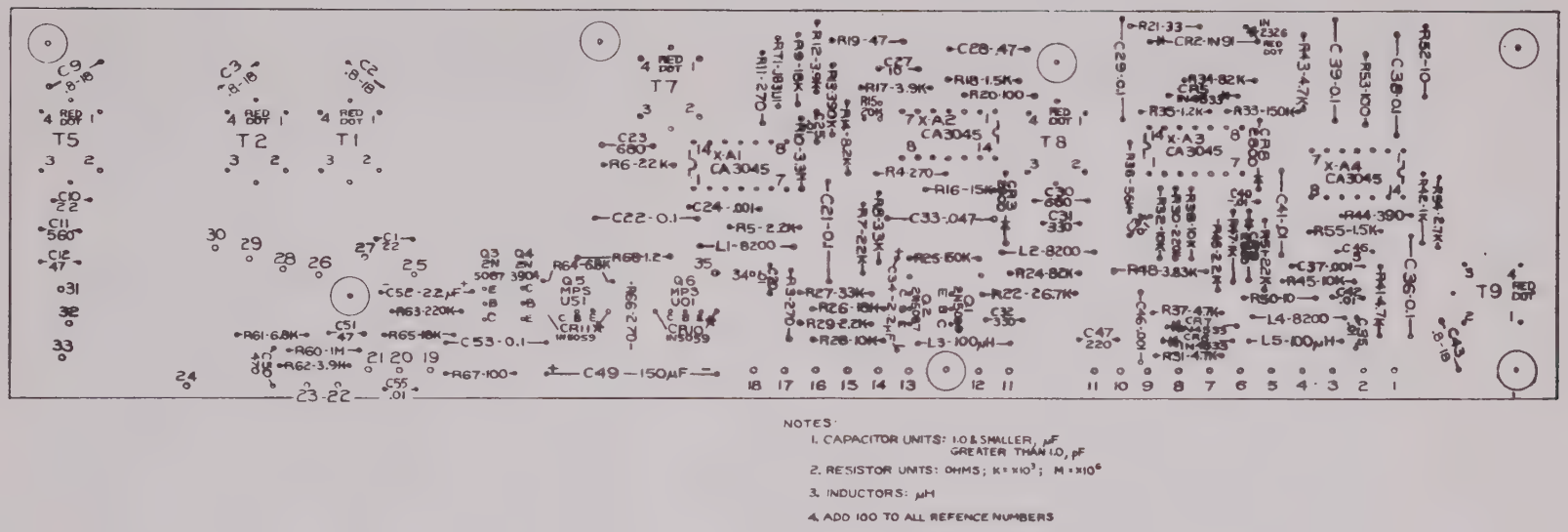


Figure 4-3 Field Strength Meter, Component Locations

4.9 Troubleshooting and Repair (Cont.)

6. If a radio station can be received, notice whether the variation in field strength reading with modulation is excessive. Variations up to about five percent may be caused by various normal conditions, but large variations may indicate a faulty voltage regulator or integrated circuit A102.

7. With the above indications as a guide, the unit may be opened (see Sec. 4.5) and checked for internal faults. First, look for mechanical faults, such as broken wires, switch problems, and loose hardware. The most likely cause of circuit failure is a bad integrated circuit (IC), which are all RCA Type CA3045. Type CA3046 may be substituted if the unit is not exposed to temperatures below freezing. A bad IC can easily be located without circuit tracing by measuring the pin voltages and comparing the results with the chart, Figure 4-1. Replace IC's in accordance with Sec. 4.7. Normally an IC can be replaced without affecting the calibration of the unit, but operation should be carefully checked after replacement.

In the case of any serious malfunction, it is desirable to contact the factory, as this may save considerable time and trouble and will be of mutual benefit to both manufacturer and user. The repair itself is best carried out at the factory, where various special test fixtures are maintained specifically for these instruments, including an RF field source of precisely-known magnitude for calibration checks after repair.

4.10 Recalibration

For assurance that long-term changes in field strength readings are due to factors other than the field strength meter itself, the instrument should be recalibrated at regular intervals. The factory maintains a calibrating field for this purpose that is held in close agreement with the standard field of the National Bureau of Standards. The factory recalibration procedure includes a thorough check and readjustment of the unit, to insure that it is working properly prior to the actual calibration, followed by adjustments in the calibrating field on all ranges to bring the unit within its original accuracy specifications. It is recommended that this be done at intervals of not more than two years in order to be assured of measurement accuracy in critical situations. Recalibration can be done across for the full frequency range or at a single specified frequency.

If at any time a question arises as to the calibration of the unit, when it is operating normally, it may be returned to the factory for an "Incoming Calibration". In this case complete measurements are made on the unit as it is received, without any readjustments, and a set of correction factors is supplied that can be applied to readings already taken. These factors include corrections for all ranges and for meter nonlinearity as well as for absolute calibration.

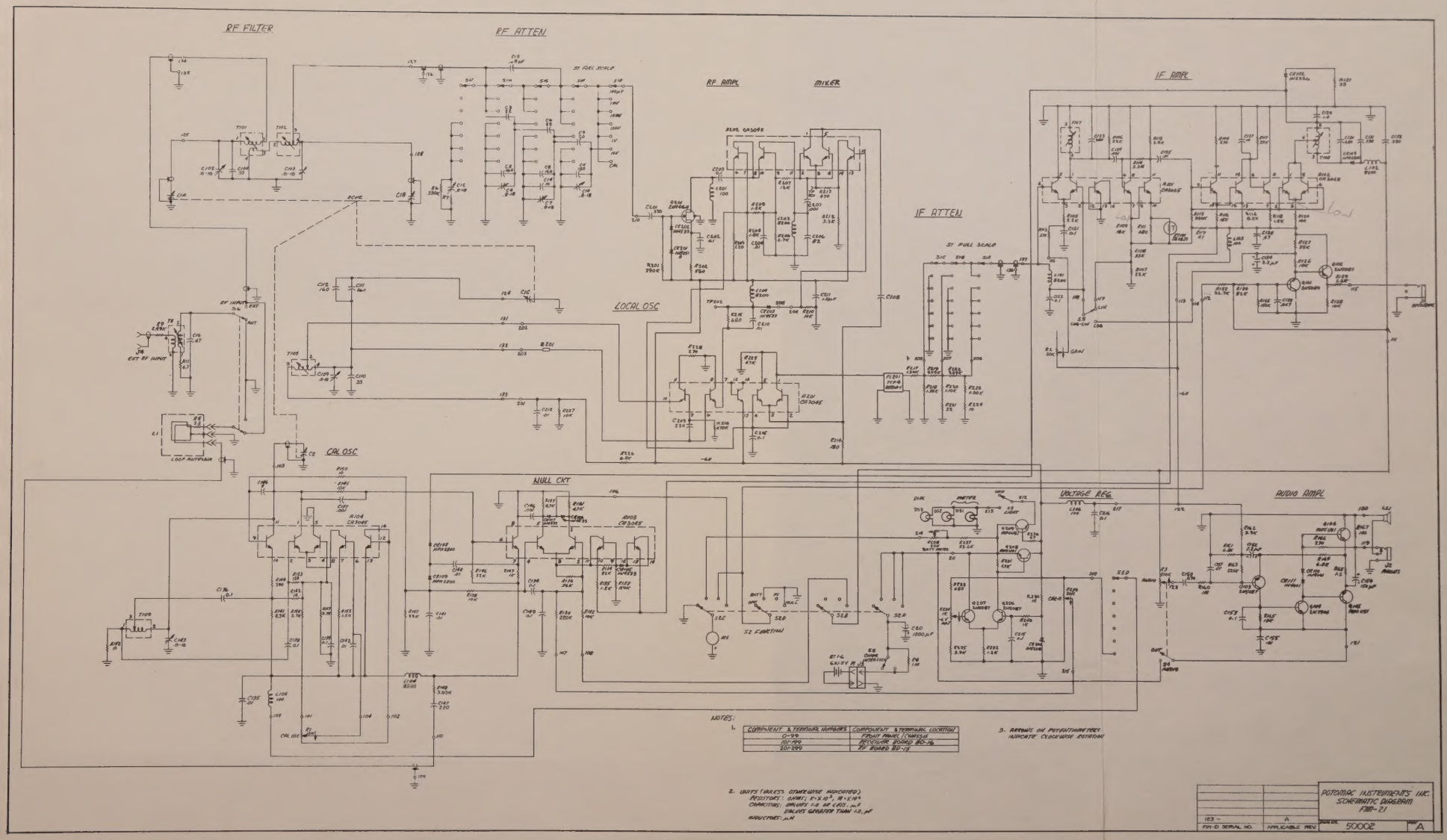
4.10 Recalibration (Cont.)

It is possible to maintain a rough calibration check by recording the reading obtained when the known output of a signal generator is applied to the external RF input, after first performing the self-calibration procedure. This is not a satisfactory substitute for calibration in a known RF field for two reasons: (1) When the external input is used, some components are used that are not used for field strength measurements, while some that are in the circuit for field strength measurements are not used with the external input; and (2) the output level of the generator for all future checks would have to be maintained within one percent of the level for the first check, which is not usually possible.

SECTION 5. SCHEMATIC DIAGRAM

5.1 General

This section contains the schematic diagram of the FIM-21.



COMPONENT & TERMINAL NUMBERS	COMPONENT & TERMINAL LOCATION
0-99	FRONT PANEL CHASSIS
101-199	RECEIVER BOARD BD-16
201-299	RF BOARD BD-15

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FIM-21 SERIAL NO.	APPLICABLE REV	DWG NO. 50002 REV A

MP MASTER
MA34178